pressure loss from a change in cross-sectional area in the direction of the header flow, which is at a nonzero angle with respect to the connecting channel matrix. This lowers the local pressure for driving the fluid across the connecting channels. This barrier can be an alternative to distributed obstacles parallel to the connecting microchannels, but could also be used along with the obstacles.

[0306] Barriers with uniformly distributed obstacles aligned parallel with the connecting channel matrix used to add a higher pressure drop loss with higher fluid equilibrium quality. The higher the quality the higher the stream's momentum and the higher pressure drop the stream has for passage through the barrier. This barrier is very effective for microchannel arrays that remove a constant heat flux from each channel. The barrier can be fixed to the outlet or inlet of the channels to equalize local flow rates through the coolant channel matrix (such as a planar array of parallel channels having 2, 5, 10 or more planar, parallel channels.

[0307] In open manifold systems, there can be room to place and fixture these external-to-the-microchannel passive manifold structures.

[0308] An orifice plate design (see **FIGS. 34***a* and **34***b*) can be used to meter flows to many parallel individual microchannels. The flow rate varies in the different cooling channels from top to bottom in the figures to accommodate the non-uniform heat flux profile on the walls in process flow direction. The flow distribution through the orifices is predicted by a flow resistant network approach and also using a computational fluid dynamics tool. In the one embodiment in **FIGS. 49***a* and *b*, the following rules are used:

[0309] 1) The temperature of the solid channel wall separating the process side and the coolant side should be maintained at a nearly constant value of 160° C. in order to create an isothermal boundary condition for the vinyl acetate monomer reaction. This is realized via flow boiling of water under pressure about 6 atmospheres.

[0310] 2) In order to achieve an economic operation, the pumping power of the coolant loop should be minimized and the steam equilibrium quality of the coolant at exit should be maximized. As such, the overall pressure drop and the total flow rate of the coolant should be minimized under the condition such that hot spots and dry out do not occur in coolant channel under all operating conditions.

[0311] Based on a selected VAM reaction model, the maximum heat flux at the reactor top (near the beginning of reaction zone) is approximately as large as ten times of the heat flux at the bottom. This type of profile requires an unequal coolant flow rate distribution as shown in the same figure under the condition of an exit steam quality of 0.3 that is determined from the Critical Heat Flux (CHF) of flow boiling. This means that at the given local heat flux and the exit quality the flow rate prevents a local hot spot or coolant dryout to occur.

[0312] By placing an orifice plate with different hole sizes at the inlets (header) to the channels, the same total pressure drop including the pressure loss in the header can be reached for the channels at the required flow rates. If for each channel a separate orifice were made, the orifice diameter would be very small (<0.1 mm) at small Reynolds number, especially if the length of the orifice is short, e.g. less than 1 mm. Due to the microscale and the large number (for example, 300) of the channels, the fabrication including the alignment would be not realistic. Thus, a configuration of orifice plate with few orifices has been designed, see **FIG. 50**, where as a function of the orifice diameter the frictional loss, turning losses from the manifold, and pressure drops are calculated. Each orifice is responsible for a group of channels so that the orifice sizes are large enough to be fabricated in a regular way and the flow regime in the orifices is turbulent that is suited for controlling the flow rate. **FIG. 50** shows the orifice size distribution of the orifice plate, the total pressure drop from coolant inlet in the header to the outlet of footer and the pressure loss across the orifices.

EXAMPLE 13

Design of a Chemical Reactor with Partial Boiling for Temperature Control

[0313] Partial boiling in microchannels adjacent to an exothermic chemical reactor (Fischer-Tropsch synthesis) has been evaluated to control the reactor temperature such that the overall productivity is held high while concurrently minimizing production of by-products. The temperature in the partial boiling chambers is near isothermal, with a temperature differential less than 10° C. across the reactor, and more preferably less than 5° C. across the reactor.

[0314] In this example, flow is controlled into a array of parallel microchannels through the use of a restrictive orifice at the entrance of each channel to create sufficient pressure drop to meter the flow to each channel in a uniform or tailored manner. Alternative methods of distributing flow into an array of channels (typically parallel channels) is described in the previously referenced patent application which is incorporated herein by reference; such methods may include the use of submanifolds within a manifold, porous media to control flow to or within channels, or differing sized gates to regulate flow into channels.

[0315] The partial boiling fluid may flow horizontally or vertically in an upflow or downflow orientation. The upflow orientation may be preferred as this would remove the issue of the hydrostatic head pressure of water in the manifold contributing to flow maldistribution. In other embodiments, an upflow of water or other fluid for partial boiling may be challenging for some reactions, such as FT synthesis, where the reaction mixture is also multiphase and a downflow orientation may be preferred.

[0316] The FT reactor described in this example contains two parts to the process microchannels, where the top half of the process channel has a process gap of 0.1016 cm (0.04 inches), and the bottom half of the process microchannel contains a process gap of 0.3048 cm (0.12) inches. Two top half 0.1016 cm (0.04 inches) channels feed into one bottom half microchannel. The two top half process microchannels are separated by heat exchange channels, where partial boiling for heat extraction occurs. A step is defined as the region where the two process microchannels of the top half join with the one process microchannel of the bottom half. The intent of the step is to create more volume for process microchannel catalyst where the volumetric production of heat has decreased from the higher level created near the reactor inlet (with fresh feeds and the highest reactant concentration).